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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/054,605	11/13/2001	Chao-Kun Hu	YOR919990336US2	8304

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EXAMINER
BROCK II, PAUL E

ART UNIT	PAPER NUMBER
2815	

DATE MAILED: 08/22/2002

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/054,605	HU ET AL.	
	Examiner	Art Unit	
	Paul E Brock II	2815	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____ .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-10,18-27,35 and 36* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-10,18-27,35 and 36* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *13 November 2001* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☒ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 4 .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other:

DETAILED ACTION

Drawings

1. The drawings are objected to under 37 CFR 1.83(a). The drawings must show every feature of the invention specified in the claims. Therefore, the first and second immersing steps must be shown or the feature(s) canceled from the claim(s). No new matter should be entered.

A proposed drawing correction or corrected drawings are required in reply to the Office action to avoid abandonment of the application. The objection to the drawings will not be held in abeyance.

Claim Rejections - 35 USC § 112

2. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

3. Claims 5 – 8 and 22 – 25 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

4. It is not clear how an atmosphere can be both inert and reducing. A reducing atmosphere, by definition, is not inert. For purposes of this office action "inert and reducing" will be considered "inert".

5. Further it is not clear in claims 5 and 22 if the metal phosphide-conductive film is the same as the conductive film in claims 1, 2, 18 and 19 respectively. Are there two different conductive films?

6. Further it is not clear in claims 8 and 25 if the metal boron conductive film is the same as the conductive film in claims 1, 2, 18 and 19 respectively. Are there two different conductive films?

7. A broad limitation followed by a narrower limitation that cancels the limitation is considered indefinite, since the resulting claim does not clearly set forth the metes and bounds of the patent protection desired. In the present instance, claim 5 recites the broad recitation of a second immersing step, and claim 6, which depends from claim 5, recites "the method of claim 5 wherein said step of second immersing is omitted" which narrows the limitation by its removal. It is not clear if the second immersing step exists in the scope of claim 6.

8. A broad limitation followed by a narrower limitation that cancels the limitation is considered indefinite, since the resulting claim does not clearly set forth the metes and bounds of the patent protection desired. In the present instance, claim 5 recites the broad recitation of a metal-phosphide conductive film, and claim 7, which depends from claim 5, recites "said conductive film is selected from the group consisting of... Pd, In and W" which narrows the

limitation because these conductive films are not metal-phosphide conductive films. It is not clear if the metal-phosphide conductive film exists in the scope of claim 7.

9. A broad limitation followed by a narrower limitation that cancels the limitation is considered indefinite, since the resulting claim does not clearly set forth the metes and bounds of the patent protection desired. In the present instance, claim 22 recites the broad recitation of a second immersing step, and claim 23, which depends from claim 22, recites "the method of claim 22 wherein said step of second immersing is omitted" which narrows the limitation by its removal. It is not clear if the second immersing step exists in the scope of claim 23.

10. A broad limitation followed by a narrower limitation that cancels the limitation is considered indefinite, since the resulting claim does not clearly set forth the metes and bounds of the patent protection desired. In the present instance, claim 22 recites the broad recitation of a metal-phosphide conductive film, and claim 24, which depends from claim 22, recites "said conductive film is selected from the group consisting of... Pd, In and W" which narrows the limitation because these conductive films are not metal-phosphide conductive films. It is not clear if the metal-phosphide conductive film exists in the scope of claim 24.

11. The term "mixtures thereof" in claims 10 and 27 is a relative term which renders the claim indefinite. The term "mixtures thereof" is not defined by the claim, the specification does not provide a standard for ascertaining the requisite degree, and one of ordinary skill in the art would not be reasonably apprised of the scope of the invention. It is not clear what types of

mixtures are defined by "mixtures thereof". What types of compounds suit the definition of "mixtures thereof"? How can this be determined?

Claim Rejections - 35 USC § 102

12. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

13. Claims 1, 2, 18 and 19 are rejected under 35 U.S.C. 102(b) as being anticipated by Dubin et al. (USPAT 5695810, Dubin).

With regard to claim 1, Dubin discloses in figures 1 – 4 a method for forming conductors with high electromigration resistance. Dubin discloses in figures 1 – 4 forming a layer of dielectric (11) on a substrate. Dubin discloses in figures 1 – 4 forming at least one trench (8) in said layer of dielectric. Dubin discloses in figures 1 – 4 forming a metal liner (15) in said trench. Dubin discloses in figures 1 – 4 forming a conductor (16) on said metal liner filling said trench. Dubin discloses in figures 1 – 4 forming a planarized upper surface of said conductor planar with the upper surface of said layer of dielectric. Dubin discloses in figures 1 – 4 forming a conductive film (17) over said upper surface of said conductor, said conductive film forming a metal to metal metallurgical bond.

With regard to claim 2, Dubin discloses in figures 1 – 4 and column 7, lines 42 – 44 wherein said step of forming a conductive film includes the step of forming said conductive film

by electroless deposition whereby said upper surface of said conductor is protected from oxidation and corrosion and provides high electromigration resistance and high resistance to thermal stress voiding.

With regard to claim 18, Dubin discloses in figures 1 – 4 and column 7, lines 42 – 44 a method for forming conductors with high electromigration resistance. Dubin discloses in figures 1 – 4 and column 7, lines 42 – 44 forming a patterned conductor on a substrate. Dubin discloses in figures 1 – 4 and column 7, lines 42 – 44 forming a conductive film over said surface of said conductor, said conductive film forming a metal to metal metallurgical bond.

With regard to claim 19, Dubin discloses in figures 1 – 4 and column 7, lines 42 – 44 wherein said step of forming a conductive film includes the step of forming said conductive film by electroless deposition whereby said surface of said conductor is protected from oxidation and corrosion and provides high electromigration resistance and high resistance to thermal stress voiding.

14. Claims 1, 9, 10, 18, 26 and 27 are rejected under 35 U.S.C. 102 (e) as being anticipated by Maydan et al. (USPAT 6372633, Maydan).

With regard to claim 1, Maydan discloses in figures 2, 3 and 6 – 7 a method for forming conductors with high electromigration resistance. Maydan discloses in figures 2, 3 and 6 – 7 forming a layer of dielectric (22) on a substrate. Maydan discloses in figures 2, 3 and 6 – 7 forming at least one trench (26) in said layer of dielectric. Maydan discloses in figures 2, 3 and 6 – 7 forming a metal liner (28) in said trench. Maydan discloses in figures 2, 3 and 6 – 7 forming a conductor (33) on said metal liner filling said trench. Maydan discloses in figures 2, 3 and 6 – 7

forming a planarized upper surface of said conductor planar with the upper surface of said layer of dielectric. Maydan discloses in figures 2, 3 and 6 – 7 forming a conductive film (34) over said upper surface of said conductor, said conductive film forming a metal to metal metallurgical bond.

With regard to claim 9, Maydan discloses in figures 2, 3 and 6 – 7, column 4, lines 62 – 67 and column 7, lines 9 – 12 wherein said conductive film is applied on the surface of said conductor by Chemical Vapor Deposition (CVD).

With regard to claim 10, Maydan discloses in figures 2, 3 and 6 – 7, column 4, lines 62 – 67 and column 7, lines 9 – 12 wherein said conductive film is W.

With regard to claim 18, Maydan discloses in figures 2, 3 and 6 – 7 a method for forming conductors with high electromigration resistance. Maydan discloses in figures 2, 3 and 6 – 7 forming a patterned conductor on a substrate. Maydan discloses in figures 2, 3 and 6 – 7 forming a conductive film over said surface of said conductor, said conductive film forming a metal to metal metallurgical bond.

With regard to claim 26, Maydan discloses in figures 2, 3 and 6 – 7 wherein said conductive film is applied on the surface of said conductor by Chemical Vapor Deposition (CVD).

With regard 27, Maydan discloses in figures 2, 3 and 6 – 7 wherein said conductive film is W.

15. Claims 1, 2, 18 and 19 are rejected under 35 U.S.C. 102(b) as being anticipated by Lee et al. (USPAT 6180523, Lee).

With regard to claim 1, Lee discloses in figures 1 – 8 a method for forming conductors with high electromigration resistance. Lee discloses in figures 1 – 8 forming a layer of dielectric (20) on a substrate. Lee discloses in figures 1 – 8 forming at least one trench (24) in said layer of dielectric. Lee discloses in figures 1 – 8 forming a metal liner (28) in said trench. Lee discloses in figures 1 – 8 forming a conductor (38) on said metal liner filling said trench. Lee discloses in figures 1 – 8 forming a planarized upper surface of said conductor planar with the upper surface of said layer of dielectric. Lee discloses in figures 1 – 8 forming a conductive film (46) over said upper surface of said conductor, said conductive film forming a metal to metal metallurgical bond.

With regard to claim 2, Lee discloses in figures 1 – 8 wherein said step of forming a conductive film includes the step of forming said conductive film by electroless deposition whereby said upper surface of said conductor is protected from oxidation and corrosion and provides high electromigration resistance and high resistance to thermal stress voiding.

With regard to claim 18, Lee discloses in figures 1 – 8 a method for forming conductors with high electromigration resistance. Lee discloses in figures 1 – 8 forming a patterned conductor on a substrate. Lee discloses in figures 1 – 8 forming a conductive film over said surface of said conductor, said conductive film forming a metal to metal metallurgical bond.

With regard to claim 19, Lee discloses in figures 1 – 8 wherein said step of forming a conductive film includes the step of forming said conductive film by electroless deposition whereby said surface of said conductor is protected from oxidation and corrosion and provides high electromigration resistance and high resistance to thermal stress voiding.

Claim Rejections - 35 USC § 103

16. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

17. Claims 3, 4, 20 and 21 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dubin as applied to claims 1, 2, 18 and 19 above, and further in view of Hong et al. (USPAT 6077774, Hong).

With regard to claims 3, 4, 20 and 21, Dubin discloses in column 7, lines 42 – 44 that the electrolessly deposited conductive film is a copper barrier layer. Dubin does not disclose that the copper barrier layer has a thickness of 9 nanometers. Hong teaches in figure 1f, column 1, lines 32 – 36 and column 5, lines 19 – 23 wherein a copper barrier layer has a thickness of 9 nanometers. It would have been obvious to one of ordinary skill in the art at the time of the present invention to use the thickness of Hong for the electrolessly deposited conductive film of Dubin in order to form a diffusion barrier with sufficiently low resistance for deep submicron copper interconnects as stated by Hong in column 1, lines 32 – 36. Deep submicron copper interconnects are desirable in order increase the speed of the chip.

18. Claims 5, 6, 22 and 23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dubin as applied to claims 1, 2, 18 and 19 above, and further in view of Zhao et al (USPAT 5674787, Zhao).

With regard to claims 5 and 22, Dubin discloses in figures 1 – 4 and column 6, lines 36 – 55 wherein said step of electroless deposition includes the steps of first immersing said substrate in a solution of metal ions whereby a layer of nanoparticles of metal are formed on said upper surface of said conductor. Dubin discloses in figures 1 – 4, column 6, lines 6 – 23 and column 7, lines 42 – 49 second immersing said substrate in an electroless complexed solution of metal ions and hypophosphite ions whereby a metal-phosphide conductive film is formed on said upper surface of said conductor. Dubin teaches that the metal-phosphide conductive film is a barrier layer. It is not clear if Dubin teaches annealing the metal-phosphide conductive film. Zhao teaches in column 3, lines 30 – 35 to anneal a barrier layer. It would have been obvious to one of ordinary skill in the art at the time of the present invention to anneal the metal-phosphide conductive layer of Dubin in order to improve the electrical properties of the plugs as stated by Zhao in column 3, lines 30 – 35. Zhao teaches in column 8, lines 63 – 65 annealing said substrate in one of an inert atmosphere at a temperature of 200° C for 1 hour whereby excellent adhesion is obtained between said conductor and said metal conductive film. Dubin and Zhao discloses the claimed invention except for the anneal at a temperature of at least 300° C and a time of at least 2 hours. It would have been obvious to one having ordinary skill in the art at the time the invention was made to have the anneal at a temperature of at least 300° C and a time of at least 2 hours, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. In re Aller, 105 USPQ 233. It is further obvious in the method of Dubin and Zhao that excellent adhesion is obtained between the conductor and the metal-phosphide conductive film during the anneal.

With regard to claims 6 and 23, as best the examiner can ascertain, Dubin and Zhao read on the claimed invention.

19. Claims 7 and 24 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dubin and Zhao as applied to claims 1, 2, 5, 18, 19 and 22 above, and further in view of Hong et al. (USPAT 6077774, Hong).

With regard to claims 7 and 24, Dubin teaches in column 7, lines 42 – 45 the conductive film is CoWP. Dubin further discloses in column 7, lines 42 – 44 that the electrolessly deposited conductive film is a copper barrier layer. It is not clear if Dubin and Zhao disclose that the copper barrier layer has a thickness of 9 nanometers. Hong teaches in figure 1f, column 1, lines 32 – 36 and column 5, lines 19 – 23 wherein a copper barrier layer has a thickness of 9 nanometers. It would have been obvious to one of ordinary skill in the art at the time of the present invention to use the thickness of Hong for the electrolessly deposited conductive film of Dubin and Zhao in order to form a diffusion barrier with sufficiently low resistance for deep submicron copper interconnects as stated by Hong in column 1, lines 32 – 36. Deep submicron copper interconnects are desirable in order increase the speed of the chip.

20. Claims 8, 25, 35 and 36 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lee as applied to claims 1, 2, 18 and 19 above, and further in view of Zhao.

With regard to claim 8, Lee discloses in figures 1 – 8 wherein said step of electroless deposition includes the steps of first immersing said substrate in a solution of metal ions whereby a layer of nanoparticles of metal are formed on the surface of said conductor. Lee discloses in

figures 1 – 8 second immersing said substrate in an electroless complexed solution of metal ions and dimethylamino borane whereby a layer of metal-boron conductive film is formed on said upper surface of said conductor. Lee teaches that the metal boron conductive film is a barrier layer. It is not clear if Lee teaches annealing the metal boron conductive film. Zhao teaches in column 3, lines 30 – 35 to anneal a barrier layer. It would have been obvious to one of ordinary skill in the art at the time of the present invention to anneal the metal boron conductive layer of Lee in order to improve the electrical properties of the plugs as stated by Zhao in column 3, lines 30 – 35. Zhao teaches in column 8, lines 63 – 65 annealing said substrate in one of an inert atmosphere at a temperature of 200° C for 1 hour whereby excellent adhesion is obtained between said conductor and said metal conductive film. Lee and Zhao discloses the claimed invention except for the anneal at a temperature of at least 300° C and a time of at least 2 hours. It would have been obvious to one having ordinary skill in the art at the time the invention was made to have the anneal at a temperature of at least 300° C and a time of at least 2 hours, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. In re Aller, 105 USPQ 233. It is further obvious in the method of Lee and Zhao that excellent adhesion is obtained between the conductor and the metal-boron conductive film during the anneal.

With regard to claims 35 and 36, Lee teaches in column 7, line 59 wherein said conductive film is NiB.

Conclusion

21. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Maex et al., Gilton et al., Ting et al., Matanabe et al., Zhao et al. and Lee et al. all teach a barrier layer over a copper interconnect. Kawasaki teaches electroless deposition using hypophosphate ions.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Paul E Brock II whose telephone number is (703)308-6236. The examiner can normally be reached on 8:30 AM-5:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Eddie Lee can be reached on (703)308-1690. The fax phone numbers for the organization where this application or proceeding is assigned are (703)308-7722 for regular communications and (703)308-7722 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703)308-0956.

Paul E Brock II
August 16, 2002

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